Vermont Agency of Transportation
Statewide Small Culvert Inventory

2010 End of Year Report

Highway Safety and Design
Asset Management Unit

March 22, 2011

Executive Summary

The Vermont Agency of Transportation owns and is responsible for the maintenance of a large, complex drainage system composed of culverts and other structures of various materials and sizes. The Agency has a well developed program to address culverts 72” or greater in diameter. The Statewide Small Culvert Inventory (SSCI) was designed as a compliment to that program intended to locate and catalog all state owned, culverts less than 72” in diameter. The inventory of these structures assesses their composition, structural condition and local site conditions. The SSCI will also provide the framework for continued monitoring and condition assessments in the future providing the framework to prioritize maintenance, repairs and replacements.

This year, the Highway Safety and Design, Asset Management Unit (AMU) inventoried 2,608 culverts and 1,405 drop inlet structures. The AMU maintains an inventory of 14,468 small culverts and 10,468 drop inlet structures. Inspection teams have investigated 735 miles of highway including 643 miles of interstate and 92 miles of state and US routes. In cooperation with the operations division another 32.9 miles have been mapped for EPA compliance in the Municipal Separate Storm Sewer System (MS4) areas.

To date the culverts barrels that were able to be assessed for condition, 93% were recorded as being in fair or better condition. With the access constraints of some small culverts, 45% were not physically able to be assessed for barrel condition. Inlet and outlet treatments were recorded at 89.5% in fair or better condition

In support of the Connect Vermont program, the SSCI has completed the interstate corridors and have successfully collected over 95% of point location within the acceptable horizontal and vertical tolerances (0.25m). The program will continue to work on routes within the Connect Vermont 5 year plan.

Work has continued with the Operations Division’s IT Unit for integration of culvert data into the MATS database. This integration would provide location and structural information as well as a tool to review and update condition data to those in the maintenance districts responsible for the culvert assets. In support of this effort a working group has been formed with representatives with IT, Operations and PDD. This group is working towards MATS integration as well as developing web reports and web mapping products to enhance the MATS information.

The SSCI has absorbed Stormwater Mapping data collected from 2002 to 2007 in compliance with National Pollutant Discharge Elimination System (NPDES) by Environmental Services Section. This year’s SSCI collection effort was expanded to include MS4 features in the anticipated MS4 area within Rutland Town. This has allowed the AMU to centralize collection and simplify reporting for the Operations Stormwater Compliance Management Program.

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Introduction

The Vermont Agency of Transportation (VTrans) owns and is responsible for the maintenance of a large, complex drainage system composed of culverts and other structures of various materials and sizes. Deteriorating culverts pose potential safety hazards to the traveling public, creating the potential for slope instability, roadbed sink holes or structural collapse. In addition to the safety concerns, the lack of knowledge regarding small culverts may also contribute to a growing economic burden for the state.

VTrans has a well developed program to address culverts 72” or greater in diameter. The Statewide Small Culvert Inventory (SSCI) was designed as a compliment to that program intended to locate and catalog all state owned culverts less than 72” in diameter. The inventory of these structures assesses their composition, structural condition and local site conditions. The SSCI provides the framework for continued monitoring and condition assessments in the future providing the ability to prioritize maintenance, repairs and replacements.

Historic inventories of these structures have contained useful information but were recorded for individual needs, at a specific time in different district or regions. Though they provided a practical, onetime assessment of that area’s structures, they were disconnected from maintenance activities and subsequent assessments. The SSCI has been designed as a digital, spatial inventory to be used for a range of uses at various levels throughout the Agency statewide. It is centrally stored and designed to be maintained through activities in the business process to ensure the inventory is kept up to date.

The Agency continues to improve the efficiency and predictability of its work and we continue to make investments towards system preservation. The SSCI is the catalyst for truly managing small culverts. The SSCI provides the geospatial baseline that will allow for better recording, prioritization and financial planning. The benefits reach Agency wide in an effort to increase the efficiency of our culvert management while ensuring the safety of Vermont’s infrastructure.

Methodology

The SSCI was developed from previous inspection efforts in the Agency, the efforts of other states and from Vermont State Bridge and Culvert Standards. Under the guidance of an Agency wide work group the methodology and data dictionary were developed. The following is a description of the data collection process and the roles of the inspection team members. For additional information and the complete field procedure please refer to the SSCI Field Manual.

Phase I – Initial Field Collection

The first phase is the initial collection phase in which the culvert inspection team makes the first attempt at system collection following the selected route locating and uncovering culverts using record plans where available. The culvert inspection teams consist of three to four members:

The first member is the culvert inspector and the general group leader. The responsibilities are as follows:

- Acquire, prepare and record information on record plans
- Scheduling, weather cancellations, daily work plans
- Assist district personnel in culvert locations using record plans
- Assist with sign packages
- Physical culvert inspection
- Completing the daily work log
- Responsible for inspection instruments

The second member is responsible for the survey component of the inspection. The responsibilities are as follows:

- Set up and operation of GPS equipment
- Proper storage and preparation of GPS equipment
- Necessary maintenance of GPS equipment

The third and, if necessary, fourth members are district personnel. The responsibilities are as follows:

- Location and identification of culvert location
- Clearing brush, trees, debris and sediment from culvert ends
- Removing drop inlet grates where necessary
- Informing inspectors about historical issues and problem locations
- Setup and Removal of sign packages

Phase II – Field Edit Collection

After completion of the field collection, survey files are uploading for the processing of the field data. Data is analyzed in the GIS environment to ensure completeness and correctness. Marked up record plans from field collection are used to review the data for missing culverts, mismatched culvert identification numbers between inlets and outlet features, multiple and missing locations. Edit locations are digitized in the office off record plan dimensions. These modifications are completed in the office if possible. Those that require field review are isolated and exported to GPS file in preparation for phase II collection.

Using the preloaded GPS unit the culvert inspection team navigates to the location of the field edits along the selected routes. The edits locations are reviewed and collected if possible. The culvert field edit team consists of a two members:

The first member is the culvert inspector. The responsibilities are as follows:

- Acquire, prepare and record information on record plans
- Utilize GPS unit to navigate other team member to edit locations
- Physical culvert inspection
- Completing the daily work log
- Responsible for inspection instruments

The second member is responsible for the survey component of the inspection. The responsibilities are as follows:

- Drive to edit locations
- Set up and operation of GPS equipment
- Proper storage and preparation of GPS equipment

Once the field collection is completed the data is reviewed and the new field edits are added to the existing database. In the GIS environment new field edit data is appended to the existing data were applicable. Culvert ends that are not located after phase II remain as missing locations in the final database.

MS4 Collection

In accordance with the National Pollutant Discharge Elimination System (NPDES) the SCI has worked in collaboration with the Operations Division to extend our phase I collection within MS4 boundaries to include the additional stormwater features and attributes. In these areas the Phase I collection is supplemented with an additional crew member responsible for MS4 mapping. The MS4 crew member responsibilities are as follows:

- Acquire, manage and upload required photos with digital camera
- Keep a daily log of weather conditions, 48 hour rainfall amounts
- Responsible for the collection, use and management of resource GPS equipment

The MS4 crew member is responsible for recording the additional information required:

- Pipes under 12 inches in diameter in drop inlets
- Curbboard
- Outfall points when drainage leaves the state drainage system
- Drainage Path from outfall discharge point
- Unknown outlet pipes entering the state system
- Open drainages within state system

As part of this effort, the MS4 crew member will also identify potential locations for follow up investigation. These locations can include the following:

- presence of potential illicit discharges into state systems
- evidence of road settling, bank erosion or sinkholes not related to a structure
- other stormwater issues of concern

Once this data has been collected it can be served out with the small culvert inventory data to complete the picture of closed systems, open drainage and potential stormwater issues as a complete package.

Logistics

The SSCI commenced in the summer of 2007 and four years of collection have been completed. Phase II collection was developed in 2009 to recollect and recover edits that were isolated through office review. Figure 1 and figure 2 below display yearly completed mileage as of the end of the 2010 field season. Figure 3 on the following page shows a map of the completed routes for SSCI phase I.

Figure 1. *Highway Miles Inventoried by Year*

Route	2007	2008	2009	2010	TOTAL
Phase I	174.2	283.2	163.9	114	735.3
Phase II	0	0	263.5	377.1	640.6

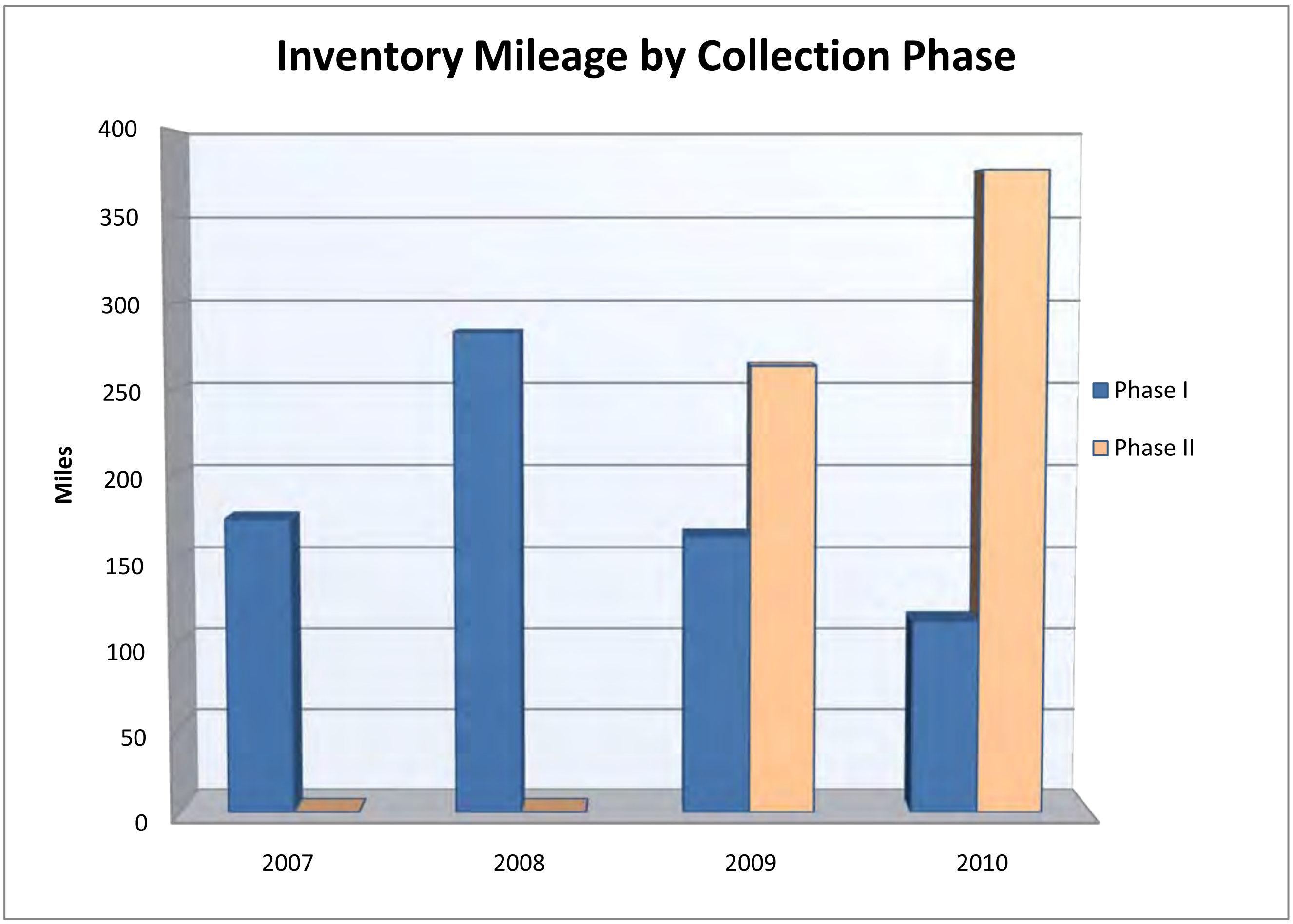


Figure 2. *Mileage completed by collection phase.*

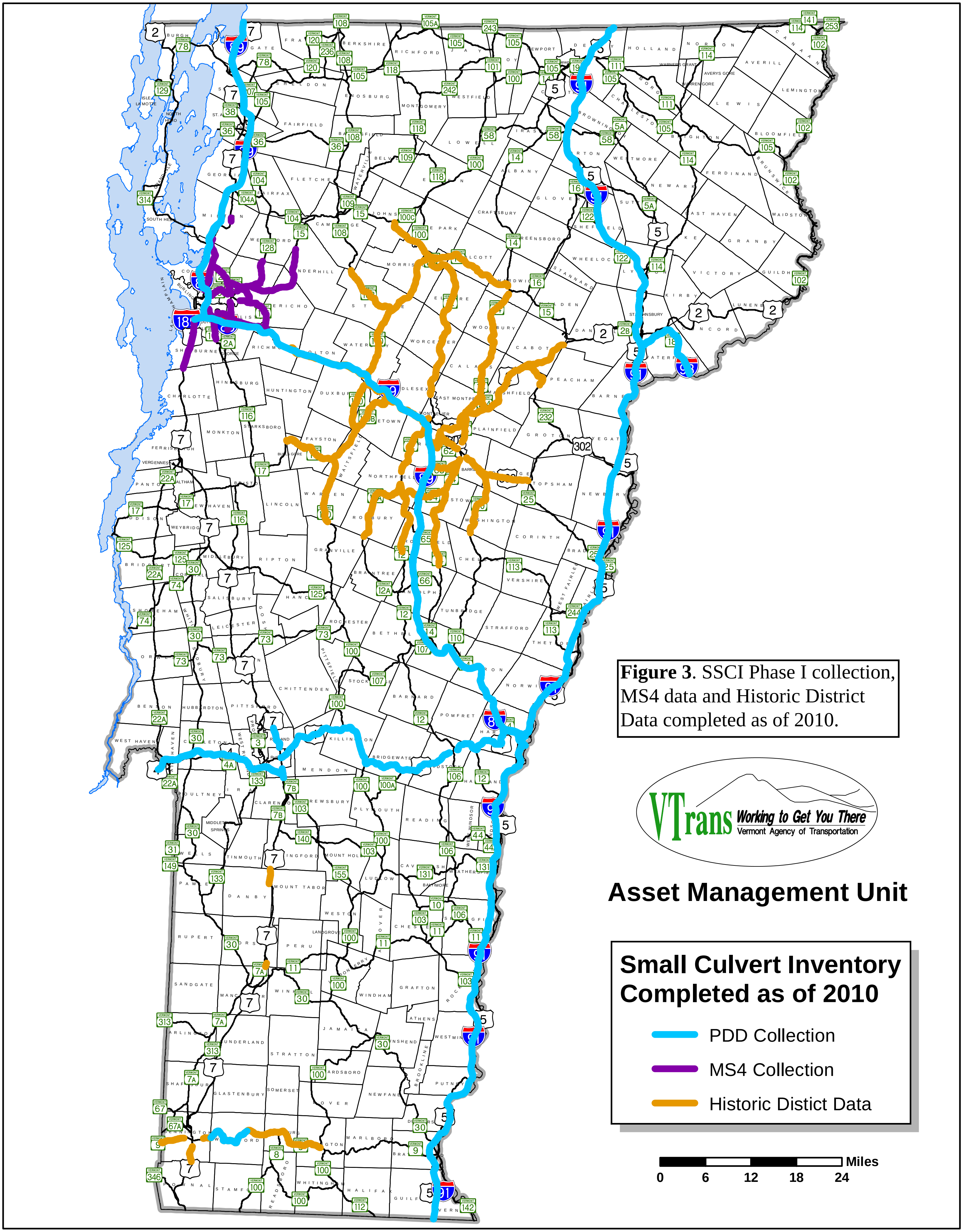


Figure 3. SSCI Phase I collection, MS4 data and Historic District Data completed as of 2010.

The SSCI has been a partnership across divisions as the Project Development Division has teamed with the Operations Division in the design and the implementation of the program. Both Divisions will have a role in the maintenance of the culvert data once it is integrated into existing asset tracking software (MATS). The success of the inventory to date would not be possible without the assistance of the Operations central office personnel as well as the effort of the District personnel. Figure 4 and figure 5 show the level of support provided by each of the Operation Districts.

Figure 4. *Mileage Completed by District*

District	2007	2008	2009	2010	Total to date
1	-	-	-	7	7
2	-	108	-	-	108
3	-	-	-	48.9	48.9
4	70	83	35.9	-	188.9
5	31.8	32.2	-	-	64
6	49	30	-	-	79
7	-	-	110.4	22.2	132.6
8	23.4	30	-	-	53.4
9	-	-	53.5	-	53.5

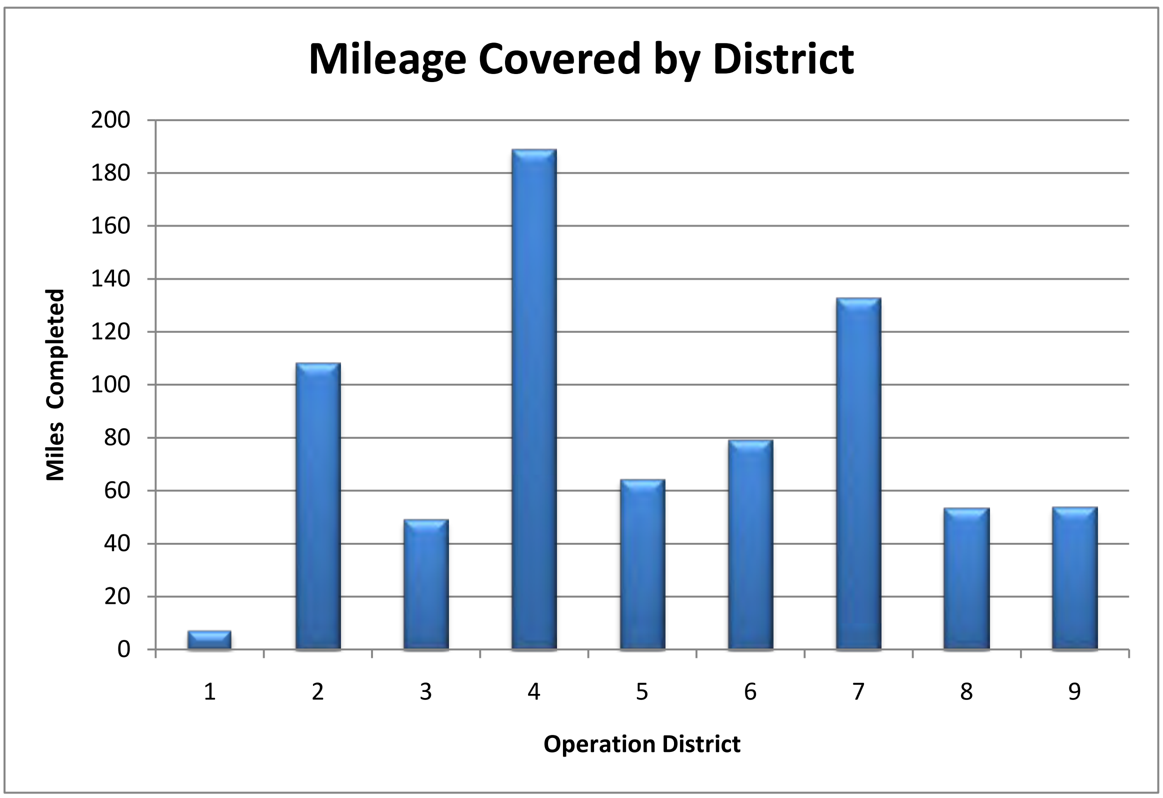


Figure 5. *Phase I mileage completed by district.*

Inspection teams move at an average rate just under one mile a day fluctuating according to the local topography, type of drainage systems, GPS reception and other field variables. Prior to the SSCI, the actual number of drainage structures statewide could only be roughly approximated. As the program's inventory continues to grow the resulting information increasingly improves the approximation of actual field conditions. Figure 6 and figure 7 below display the average number of culverts and drop inlet structures per mile on state maintained highways. Extrapolated out to the entire state system this equates to approximately 60,000 culverts and 40,000 drop inlets.

Figure 6. *Drainage Features per mile by Highway Class (including MS4 collection).*

	Culverts	Drop Inlets	Miles	Culvert / Mile	DI / Mile
Interstate	10885	8447	643.5	16.9	13.1
US Highways	2325	1357	109.0	21.3	12.4
State Highways	1332	701	53.1	25.1	13.2
All Highways	14542	10505	805.6	18.1	13.0

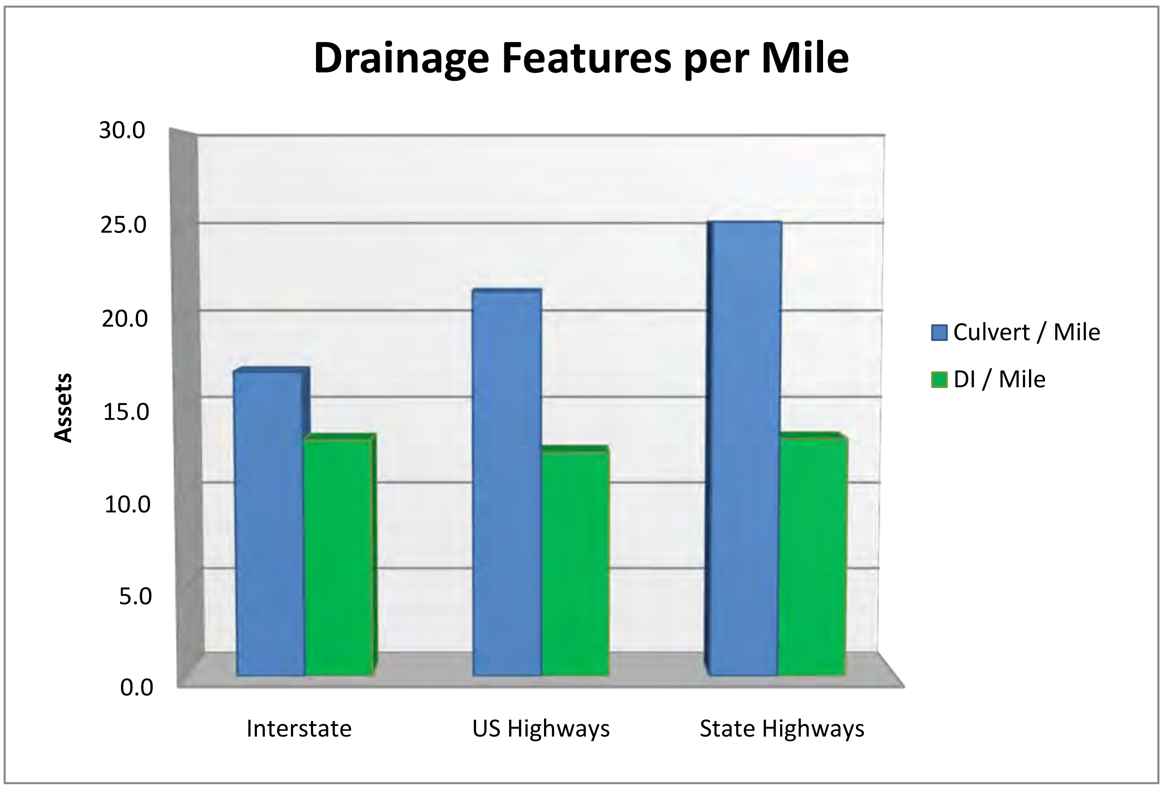


Figure 7. *Drainage feature per mile by highway class.*

<u>Culvert Assessment</u>

For all culverts under 72" in diameter, the SSCI is acquiring a GPS location at each end to define the spatial characteristics of each culvert including length, orientation, slope, direction and general system layout. At both of these recorded locations, a physical assessment is also completed for the end treatment. At the culvert end that is determined to be the outlet, an additional assessment regarding the culvert barrel is completed. These assessments generalize conditions for the structural components as well as a review of environmental and site conditions that are affected by or relating to the culvert and associated drainage.

Spatial Locations

The creation of the SSCI was driven by interest in an asset management approach to small culverts. At the inception of the program, it was identified that Connect Vermont, a fiber optic project was going to require similar data to design the installation of their utility lines. The partnering of the two divisions provided more accurate location data for the SSCI but required more stringent accuracy thresholds. To satisfy these requirements the inventory was to collect all of the locations of culvert inlets and outlets using survey grade GPS equipment, enhanced by Real Time Kinematics (RTK). These units are capable of collecting data within several centimeters both vertical and horizontal.

Unfortunately, in some areas a high accuracy GPS location has proven extremely difficult. Steep roadway side slopes, close ledge cuts and thick tree canopy has had significant affect on locational accuracy. To use this technology requires an internet connection via a cellular modem. In areas of the state this has provided real challenge even with the capability of using two major cell phone network providers. Without a consistent internet connection this technology becomes ineffective for this application.

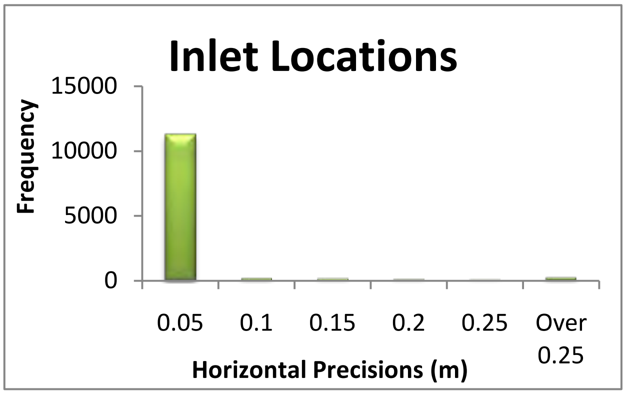
Along with the shots that lacked accurate GPS locations, there are also numerous locations where the drainage structures are buried. Field crews are instructed to use the record plan dimensions and metal detectors to attempt to locate pipe ends and drop inlets, but in some locations this still proves to be unsuccessful. These buried drop inlets and pipes have been found as deep as three feet under sediment. Culvert ends with no location information are then digitized in the office at a scale of 1:2,000 from ortho photography and utilizing dimensions found on record plans if available. In some locations, data has been mined from a combination of other efforts such as route survey data from design projects, the pilot program for the SSCI and the stormwater mapping project in the MS4 area. This mix of sources allows users access to the best available data while a location type in the attribute table is included in the database to isolate those shots taken with different methods of collection. Figure 8 shows the different type of locations and their relative composition of the inventory in respect to prospective Connect Vermont routes. As illustrated, over 96.2% of point locations have been located using survey accuracy methods. The remaining locations digitized in the office represent drainage structures not located or buried in the field. Once digitized off the record plans, an attempt will be made during the phase II of collection to locate these structures.

Figure 8. *Culvert end positions by location type*

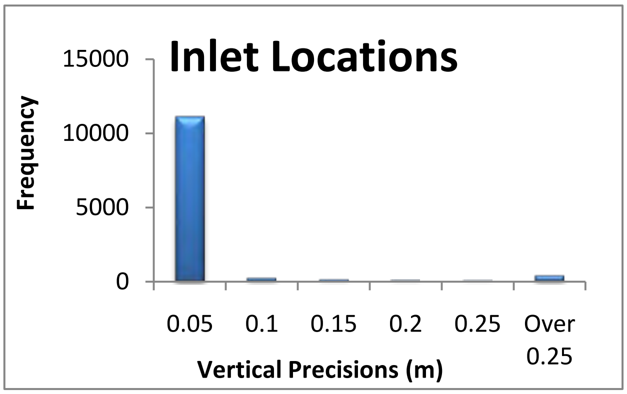
	Loc_Type	Inlet	Outlet	Pipe Ends	%	%
Survey Accuracy GPS	**1**	12139	12167	**24306**	**94.5%**	**96.2%**
Existing Project Survey	**3**	224	220	**444**	**1.7%**	
Resource Grade GPS	**2**	47	12	**59**	**0.2%**	**0.5%**
Taken from MS4	**6**	47	33	**80**	**0.3%**	
Digitized in Office	**4**	383	413	**796**	**3.1%**	**3.2%**
Derived from Other Location	**5**	3	2	**5**	**0.0%**	
Digitized off Georeferenced Plans	**7**	14	12	**26**	**0.1%**	
Total		**12857**	**12859**	**25716**		

Of the locations described as survey grade points, the majority were collected using survey grade GPS equipment. Factors in the field dictate how well and to what degree this equipment could perform. Calculated with each of the GPS location is a horizontal and vertical precision calculation derived from the multiple observations taken at each location. Though this precision calculation is not a direct calculation of accuracy it can give us a very good indication of the shot quality. Figure 9 display values for horizontal and vertical precisions recorded with survey accuracy GPS locations for inlet and outlet locations.

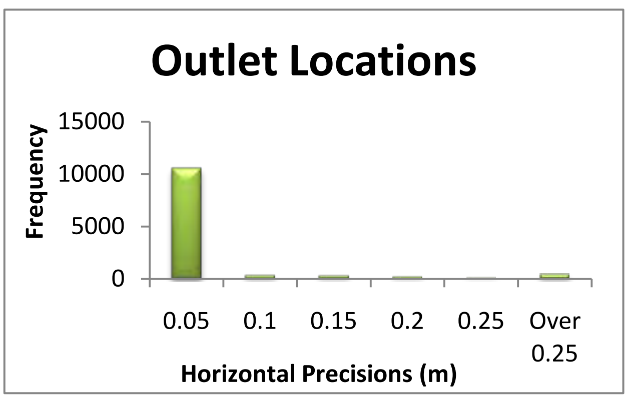
Figure 9. *Horizontal and vertical precisions for inlet and outlet locations acquired using survey grade GPS equipment.*



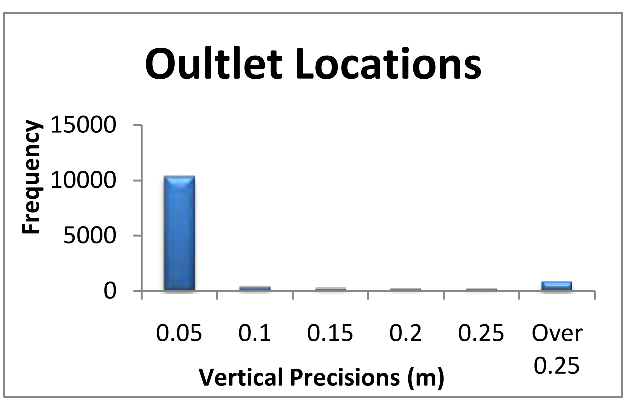
Horizontal Precisions (m)	*Frequency*	*Cumulative %*
0.05	11304	93.94%
0.1	197	95.58%
0.15	140	96.74%
0.2	103	97.60%
0.25	66	98.15%
Over 0.25	223	100.00%



Vertical Precisions (m)	*Frequency*	*Cumulative %*
0.05	11118	92.40%
0.1	244	94.42%
0.15	116	95.39%
0.2	102	96.24%
0.25	74	96.85%
Over 0.25	379	100.00%



Horizontal Precision (m)	*Frequency*	*Cumulative %*
0.05	10601	88.10%
0.1	360	91.09%
0.15	296	93.55%
0.2	213	95.32%
0.25	118	96.30%
Over 0.25	445	100.00%



Vertical Precisions (m)	*Frequency*	*Cumulative %*
0.05	10348	86.00%
0.1	330	88.74%
0.15	217	90.54%
0.2	189	92.11%
0.25	161	93.45%
Over 0.25	788	100.00%

A precision tolerance was established by the Connect Vermont program for culvert location data on prospective fiber optic routes. The established threshold is vertical precisions no greater than 0.25 meter (approximately 10 inches). As shown in figure 9, over 95% of all culvert end locations (96.85% of inlet locations and 93.45% outlet locations) are within the acceptable threshold. It is important to note as well that 89% of culvert end locations were captured with vertical precisions within 0.05 m (approximately 2 inches). Location type, horizontal and vertical precisions are included in the Small Culvert GIS feature classes to help users understand the limitations of the data.

After processing the culvert field data collected in the Phase I effort, the data is reviewed in the office for completeness. During this process not found or missing locations are digitized for recollection. Locations with a vertical or horizontal precision in excess of 1 meter are also added to the collection file in an attempt to improve the accuracy of those locations. Figure 10 shows the results of the 2010 field season phase II efforts.

Figure 10. *Types of Edit Locations*

	Locations Checked	Updated	Confirmed Not Found	Does not Exist	No Access	No Cell/Sat
Inlet	630	395	185	23	20	7
Outlet	739	538	136	26	28	11
Drop Inlet	356	171	155	17	10	2

Teams were successful recovering and updating 64% of the locations in the Phase II collection. In this effort they were able to improve 91% of the culvert end locations with poor precisions. With this process vertical precisions of this collection were improved from just over 2 meters to less than 0.2 meters, and resulted in an overall vertical improvement of 1.89 meters.

Figure 11. *Summary of Phase II Poor Precision Improvement*

	Poor Precision Points	Improved Precisions	% Improved
DI	18	18	100.0%
Inlet	26	25	96.2%
Outlet	98	87	88.8%
Total	142	130	91.5%

Structural Data

On the individual asset level, structural attribute data describes what the asset is, how it is used in application and what treatment structures are associated with it. On the system level it allows us to understand system composition and statewide quantities. This kind of statewide or regional understanding provides the Agency an understanding of the economic value and needs are regarding statewide small culverts. Attributes collected in this portion of the assessment include the following:

- Orientation
- Type
- Material
- Dimensions
- End treatments
- Depth of cover material
- Tie in points to other systems

One important variable directly related to safety is the orientation of the culvert. Culverts that pass under the traveled way potentially have greater safety risks associated with them. The orientation in this case is defined as a cross culvert. Those culverts that don't cross centerline are further defined as lateral, slope, drive or other. Figure 12 below shows that 60% of the inventoried culverts to date cross under the state's roadways. This information will be important factor in prioritization of culvert replacement and repair.

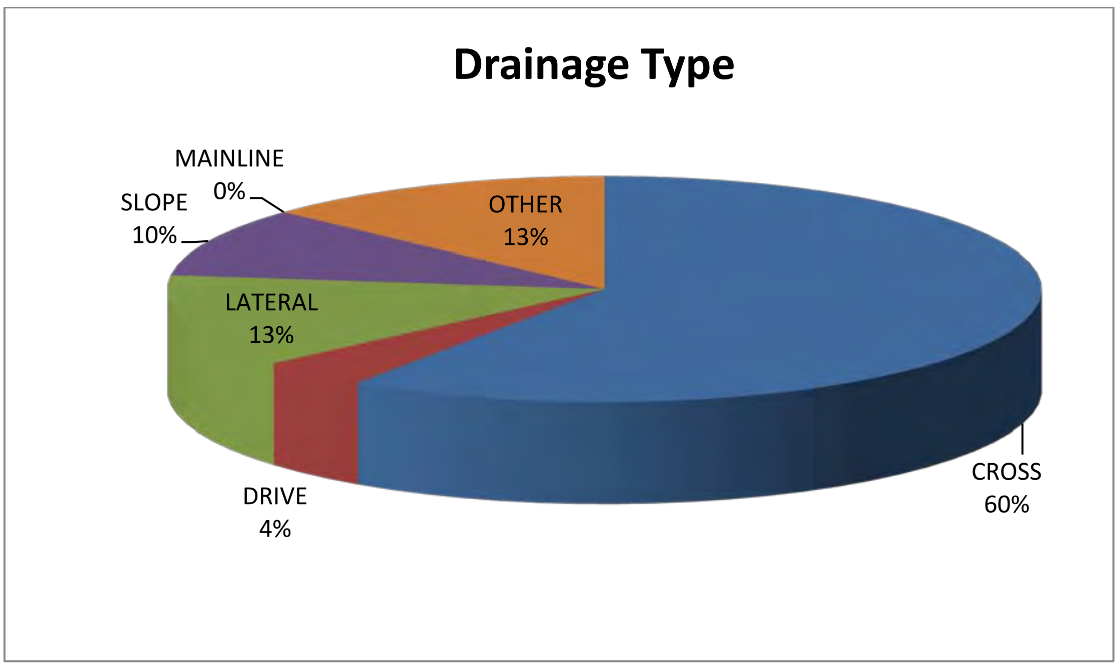


Figure 12. *Drain Type of the highway system inventoried to date.*

Another attribute that will help us describe the culvert asset is the type of system the culvert is part of. Closed drainage is defined in this inventory as a culvert that is connected to one or more culverts by any means other than open drainage or natural conveyances. Closed systems are generally connected by drop inlet structures, junction boxes or access holes and may require slightly different repair and maintenance strategies than single culverts. The dataset shows 55% of culverts are part of a closed system while the remaining 45% of the system composed of single pipes (figure 13). It is also pertinent to refer back to the inspection methodology in which a visual inspection of the culvert is conducted at the inlet and the outlet. In closed systems, inlets and outlets are contained in connection structures such as drop inlets, access holes and junction boxes and the ability to visually inspect closed culverts is certainly restricted and in most cases impracticable in this type of coarse level inspection.

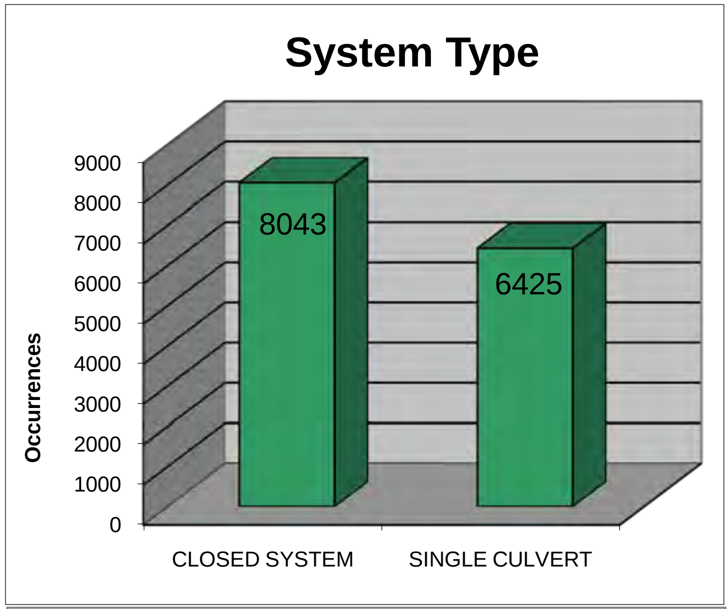


Figure 13. *System Type classification closed system versus single culverts.*

Perhaps the most basic variable that affects culvert performance over time is that of material. The dataset revealed several simple, material trends for culvert barrel material type (figure 14). As to be expected, Corrugated Galvanized Metal Pipe (CGMP) and Reinforced Concrete Pipe (RCP) comprised the largest subset of the data combining to encompass over 90% of all culverts inventoried. Also, as expected, aluminum, stone and various types of plastic account for only a small portion of inventoried culverts.

This structural data is defining the composition of our statewide drainage system and building a better understanding of what exists in the field. This data will provide the foundation for our prioritization models in the future.

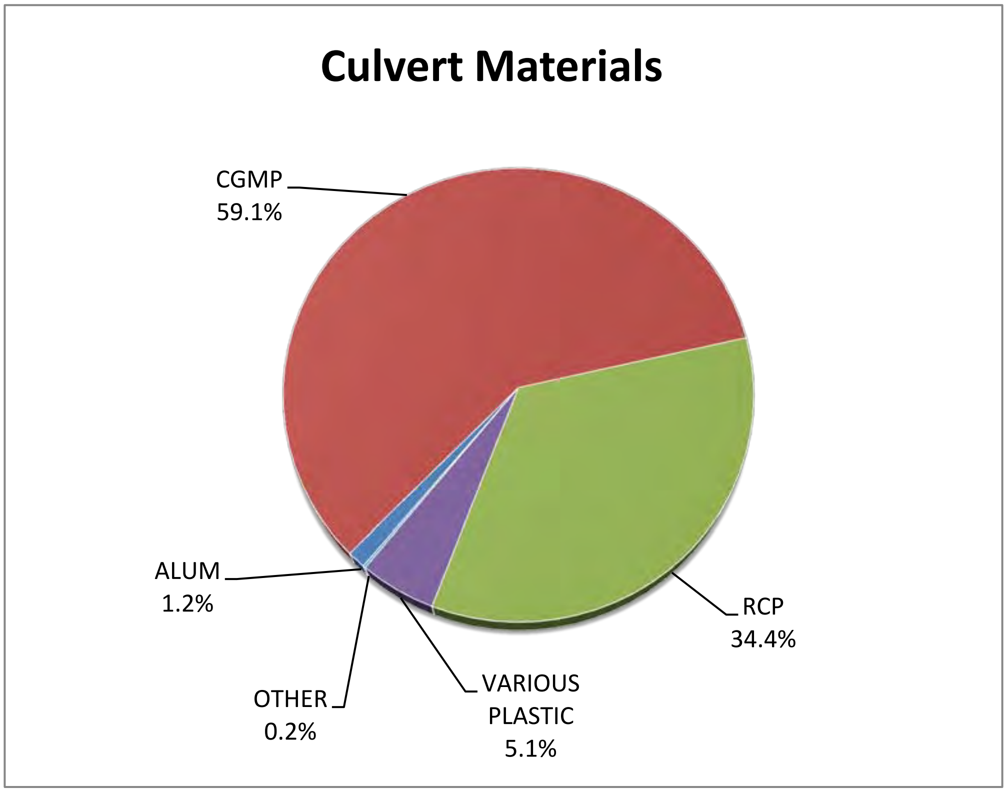


Figure 14. *Culvert Materials for inventoried structures.*

Conditional Data

At each culvert a condition assessment is conducted for both culvert ends and the barrel itself. As discussed in the limitations of the closed system inspection, the visual inspection is used in combination with a series of flags that would indicate possible structural or maintenance issues. Variables associated with roadway surface, shoulder stability and erosion provide a means of identifying culverts that may have structural deficiencies not apparent to the visual inspection process. This generalized condition information will prioritize both culvert repair and maintenance needs while building the foundation to monitor culvert deterioration over time. Attributes collected in condition assessment include the following:

- Inlet treatment condition
- Outlet treatment condition
- Barrel Condition
- Pipe section separation
- Projecting culvert ends
- Stone pad
- Sediment
- Erosion
- Road surface conditions
- Shoulder sink holes
- Piping

For each culvert the major components of inlet, outlet and barrel are assessed. Condition ratings are assigned in compliance with the condition descriptions found in the SSCI field manual. Figure 15 shows the distribution of conditions for culvert inlets and outlets statewide. The distribution of the culverts ends over the system can be described as displaying a similar distribution of condition for both inlets and outlets. Both inlet and outlet treatments have been accessed with 90% of culvert ends in fair or good condition.

Figure 16 illustrates culvert barrel conditions by linear foot. It is quickly evident that a large distribution of culverts are assigned a barrel condition of "Unknown" These culverts, as described earlier, were not able to be accessed during the inspection. This group makes up 48% of culvert linear footage and will rely heavily on the conditions of culverts in the vicinity and surface flags that indicate possible problem areas. Of the culvert barrel that was accessible to visual inspection shown in figure 17, 93% of the linear footage is considered in fair or better condition.

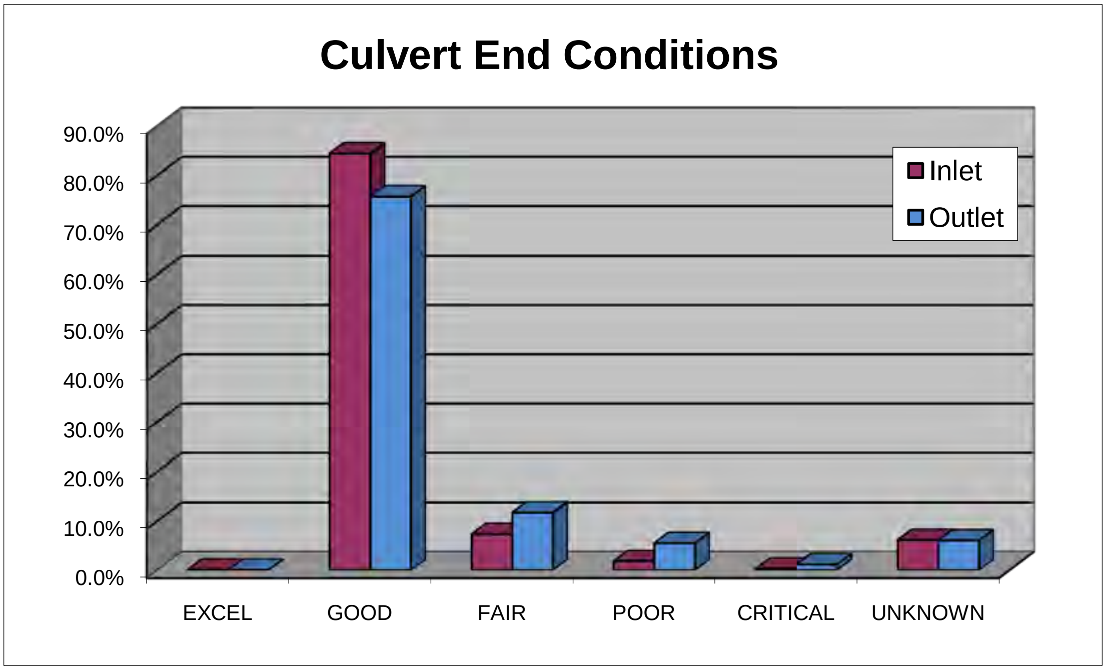


Figure 15.*Statewide condition rating values for inlet and outlet treatments.*

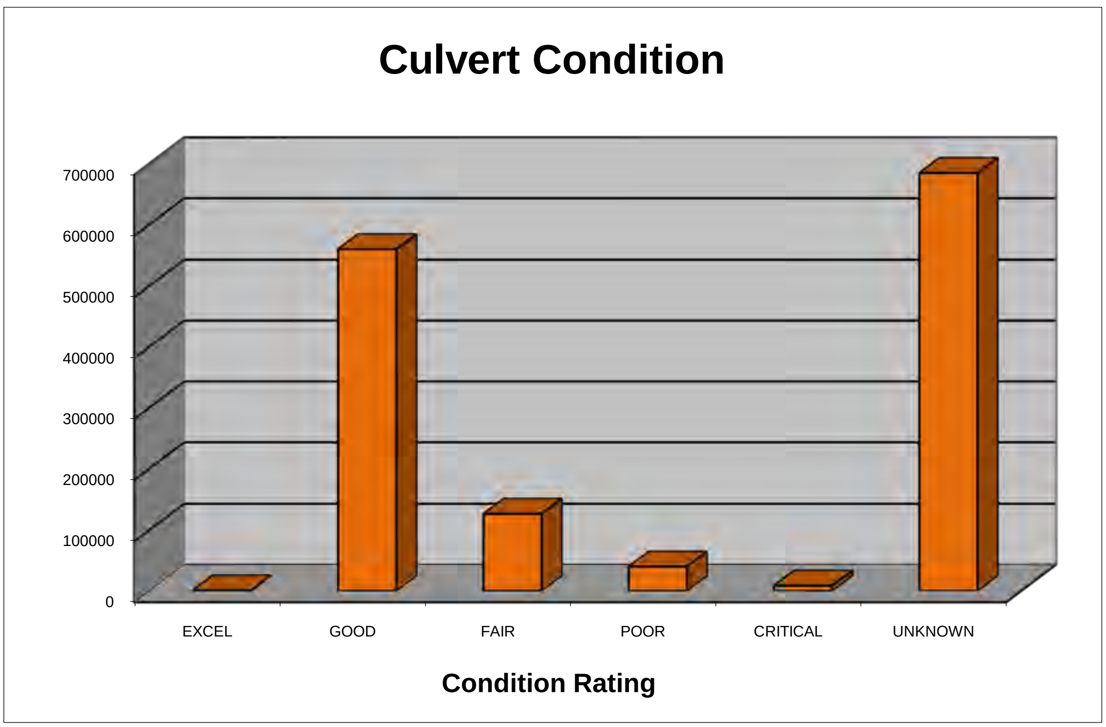


Figure 16. *Statewide barrel culvert conditions by linear foot.*

Viewing culverts from the state system as a whole can provide a good indicator of the relative health of the system and provide the foundation for future performance measures. Summarizing this data by regions such as Operations Districts provides a relative measure to view conditions as they vary by different areas of the state (figure 17). It is important to remember these are relative percentages and that the number of assets collected in some district can be relatively small.

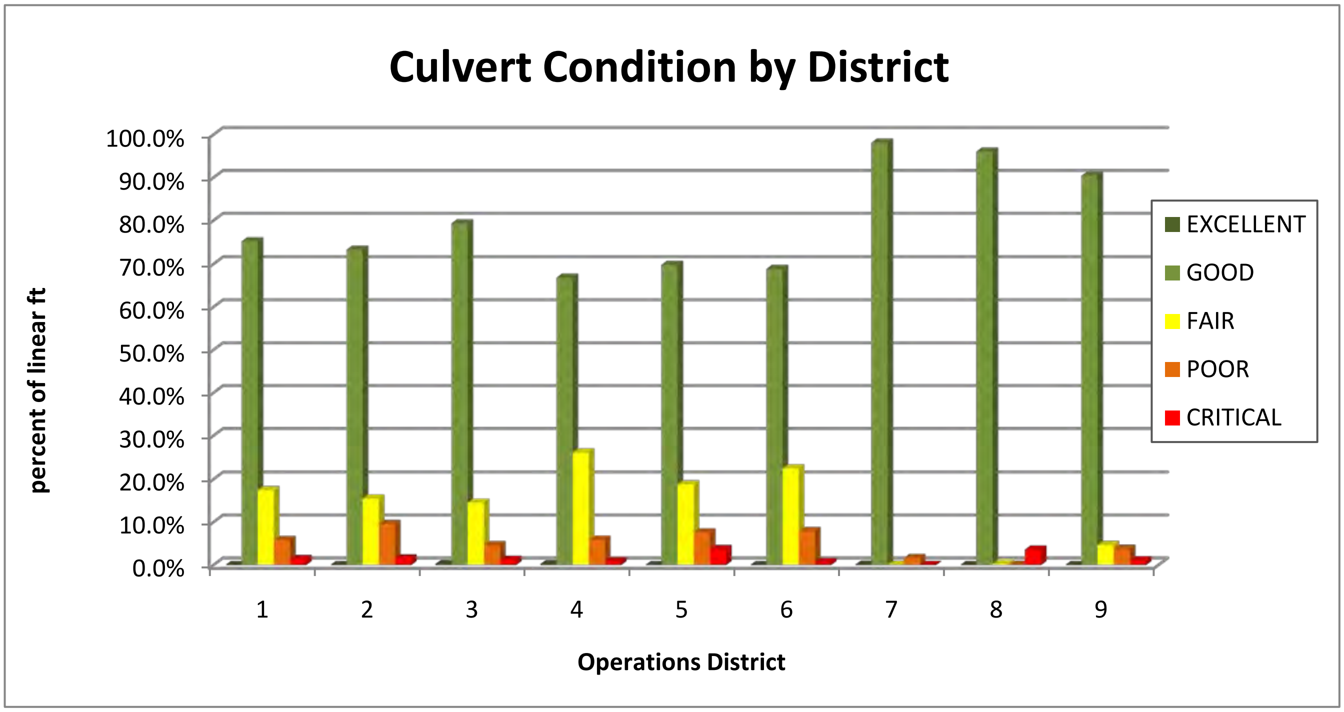


Figure 17. *Condition rating values for inspectable culvert by Maintenance District.*

The data can also be used to compare the condition of routes as is shown in figure 18 on the next page. It appears that I93 stand out with less culverts in the critical, poor and fair categories combined as would be expected from the routes relative young age.

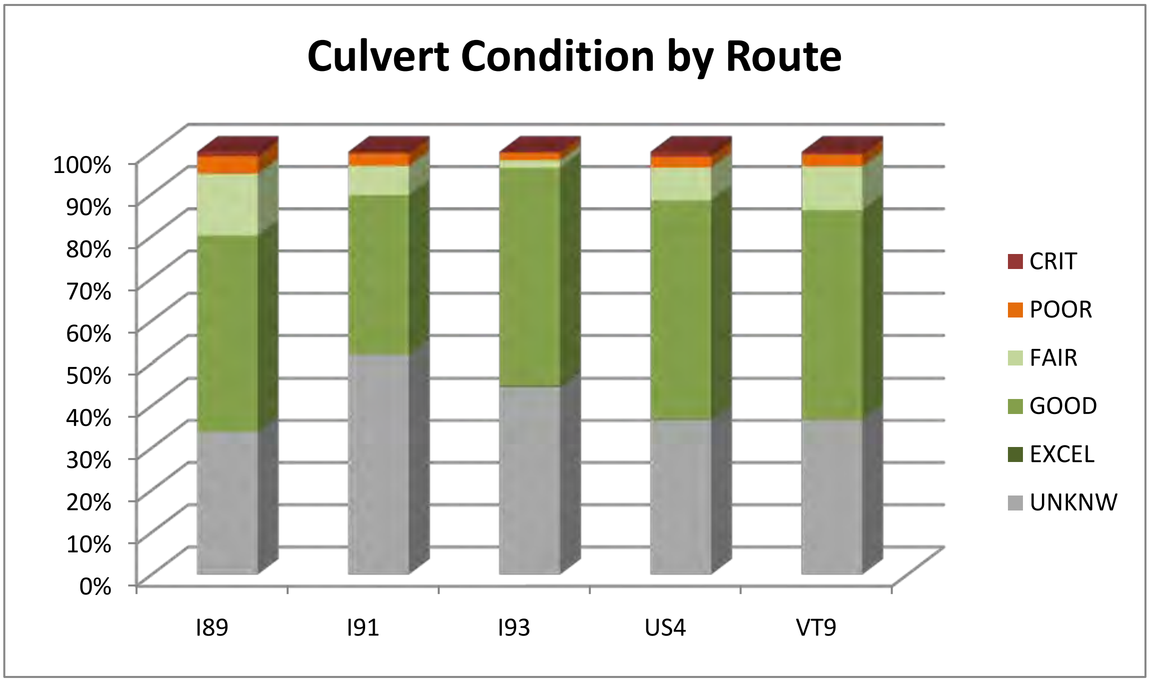


Figure 18. *Condition rating values by inventoried route.*

To help deal with the issue of non-inspectable culvert barrels, field inspection teams also review site conditions and maintenance considerations that could lead to or can indicate culverts performance issues. Beyond inspecting the physical structure of the culvert, there are several non-structural variables recorded at the culvert ends such as a stable stone pad, sediment levels, erosion and piping. The teams also inspect the culvert area for material settling in roadbed and embankment sink holes. The two major issues evaluated bellow are the presence of sediment accumulated in drainage structures and the erosion of slopes in proximity of the culvert inlet and outlet (figures 19 and 20). Though sediment and erosion issues occur throughout the state system the relative occurrence is relatively low. Heavy or plugged sediment accounts for less than 5% of all culvert ends while moderate or severe erosion is recorded at less than 3% of culvert end locations.

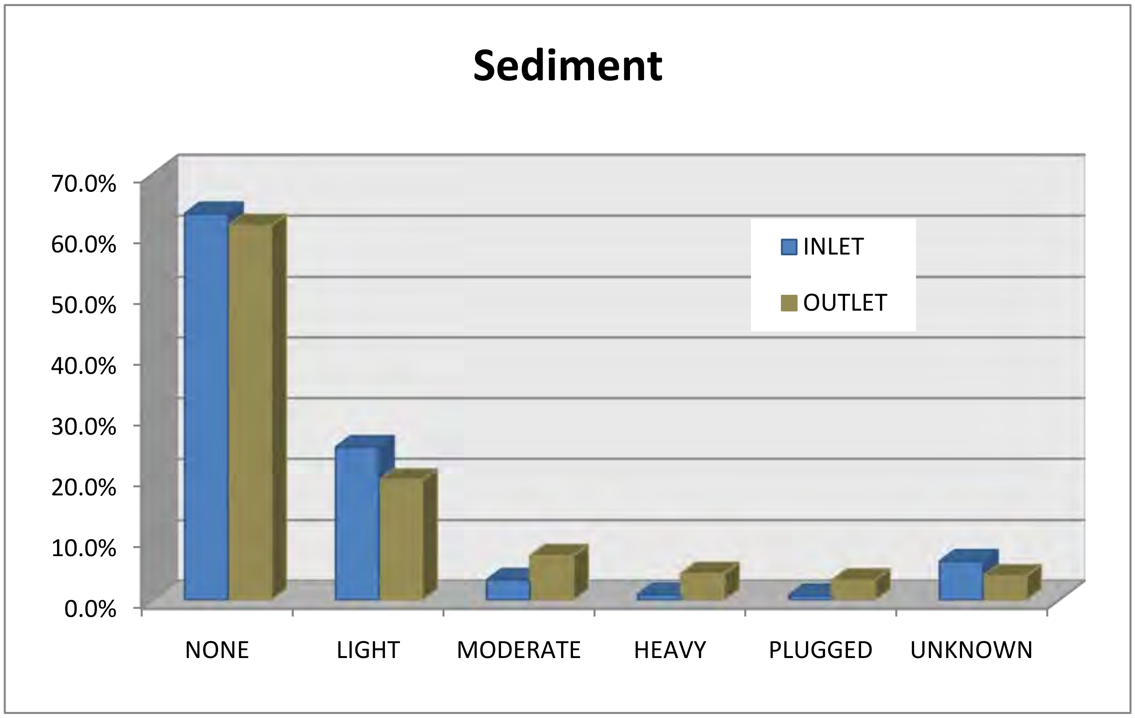


Figure 19. *Sediment rating values for inlet and outlet culvert ends.*

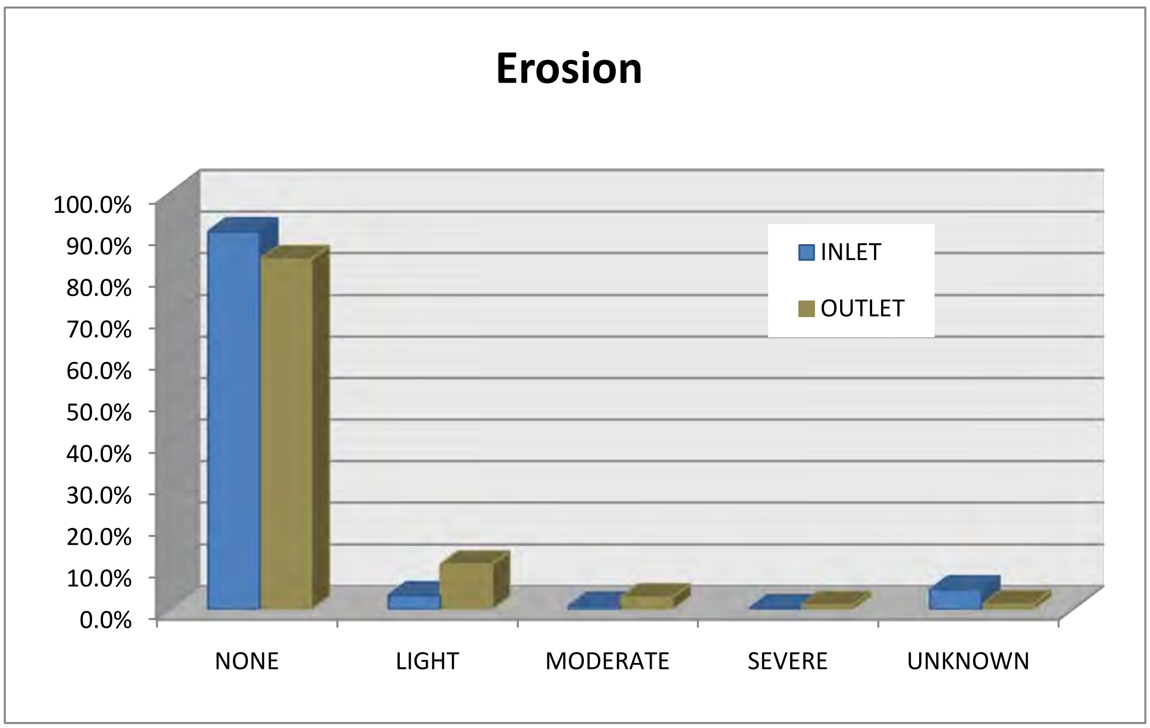


Figure 20. *Erosion rating values for inlet and outlet culvert ends.*

Data Analysis

As we acquire a more diversified dataset containing multiple routes, assets from different regions of the state and structures constructed in different time periods, we continue to improve our approximation of actual field conditions. At this point observations can be made and trends start to become apparent.

Material is a prime example of a variable we can investigate for emerging trends. It is understood that this variable is very important in determining the design life of a culvert and the deterioration curve associated with it. Judging by figure 21 it appears that various types of plastic pipe (consisting of mostly CPEP) is in the best current condition on our highway system. Though this appear to be true we cannot assume they exhibit the greatest longevity, as plastic pipes have only relatively recently been used as a culvert material. Over time we would expect to see overall conditions of plastic pipes degrade similar to the other material types. Figure 21 also demonstrates the relationship between reinforced concrete pipes (RCP) and corrugated galvanized metal pipe (CGMP). As discussed earlier and shown in figure14, these two material types compose over 90% of the highway drainage system. By organizing condition by material we see that RCP culverts have been assessed to be in better condition than CGMP with 13% more culverts in the good condition rating.

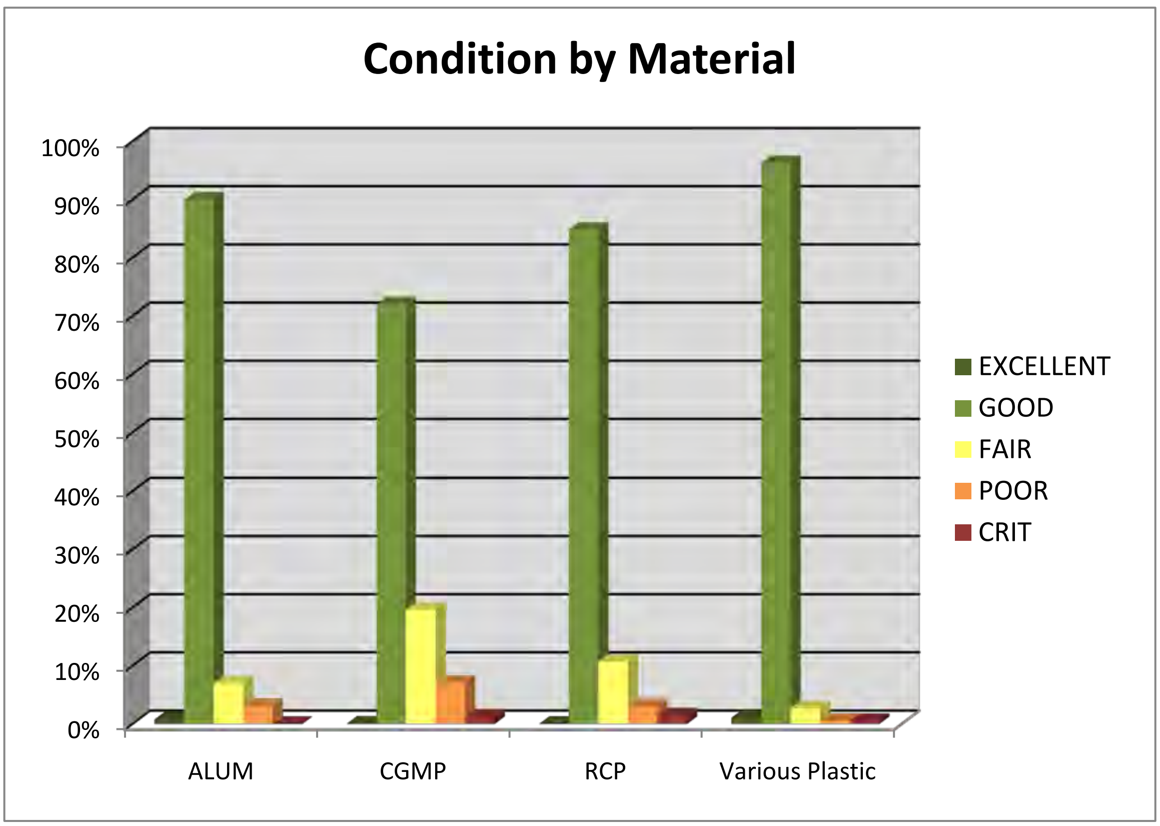


Figure 21. *Condition by culvert barrel material.*

As discussed previously and exhibited in figure 21, conditions were not conducive to culvert inspection at 48% of culvert barrels. An attempt to address this issue was covered with the collection of site conditions and surface variables used as indicator flags. Utilizing the culvert condition ratings that were applied to inspectable culverts in conjunction with the sink hole rating that was recorded at the same locations, we can see in figure 22 that there appears to be a correlation between condition and the presence of sink holes. Culverts with sink holes present are more likely to be rated in poor or critical condition. The positive correlation tells us we can, with some level of confidence, identify potentially critical or poor culverts that we are not physically able to inspect, though the use of surface level flags such as sink holes.

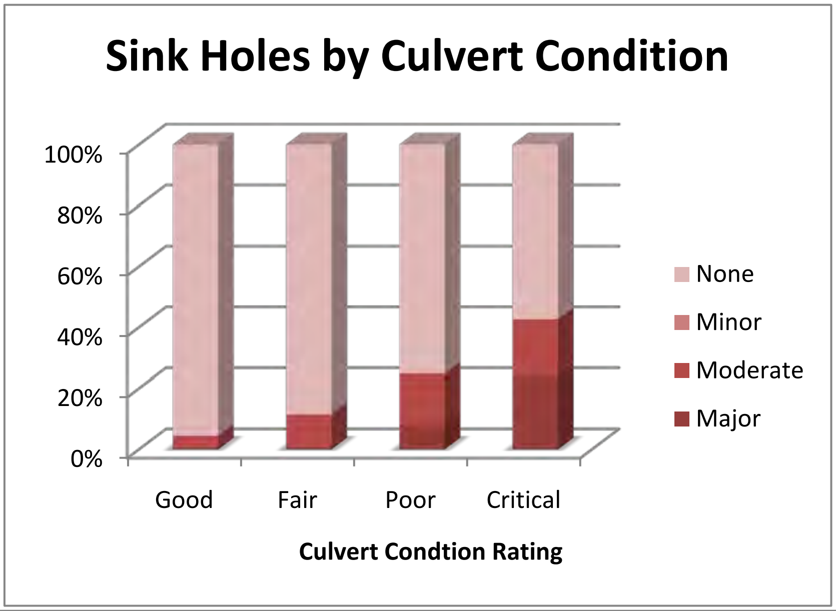


Figure 22.*Corrolation of sinkholes and culvert conditions for inspected culverts.*

The Small Culvert Inventory was designed with the goal of feeding culvert data into a management system that could be used to prioritize replacement and maintenance projects. The information the SSCI program is collecting provides the necessary foundation for this system. A critical piece of the management system is the modeling of the asset's deterioration. One critical piece of the deterioration is culvert age. For some sections of highway we have clear installation dates while in other areas the dates are completely unknown. Using Interstates and associated opening dates, we can start to analyze how the assets deteriorate over time. Figure 23 shows this deterioration by looking at the conditions of culverts that were built in different time periods.

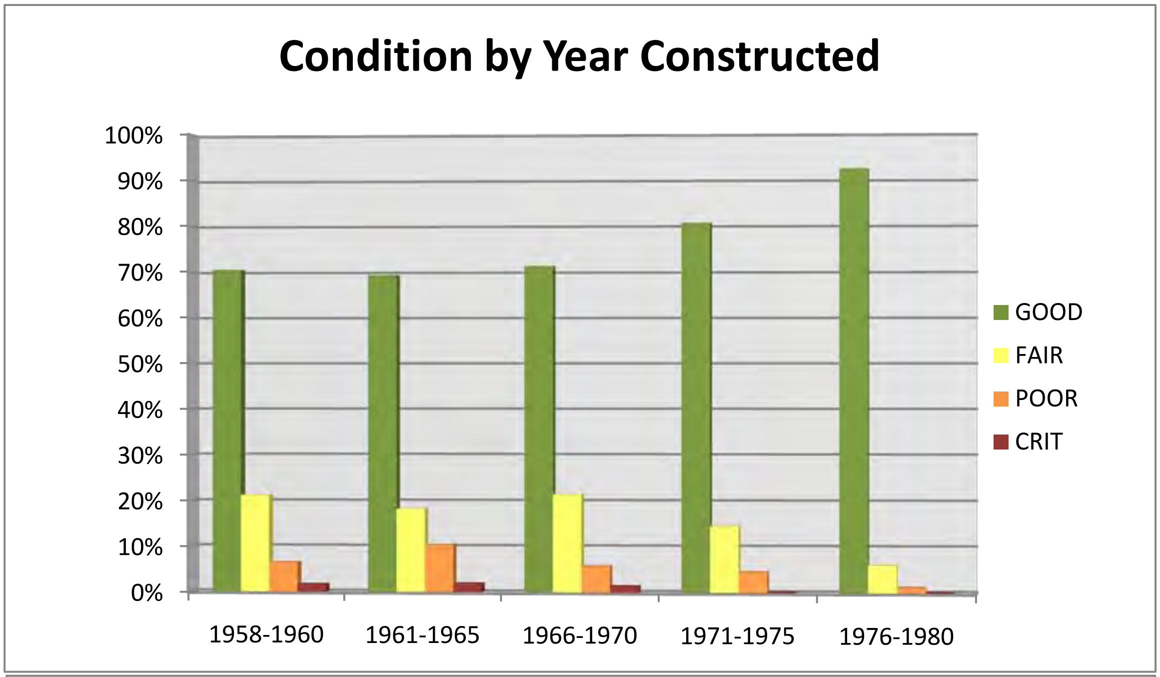


Figure 23. *Condition by year of construction.*

Using the existing data to make decisions on the entire network may have its limitations today but as we acquire a more data and improve the data diversity, we can develop increasing confidence in the dataset. Ultimately this dataset will provide the base for a project level prioritization tool as well as a foundation for decisions at the policy level.

Non-Inventory Advances

In May 2010 the Small Culvert Data Integration Group was formed with members from the Project Development Division, Operations Division as well as Information Technology. Both divisions have an interest in the Small Culvert Inventory data and both divisions participate in actions that affect and could potentially update those assets. With this understanding of the data needs, the Small Culvert Data Integration Group has initiated the process of integrating existing culvert data from the SSCI into the MATS application. The complexity of the MATS database has proven to be more challenging than originally expected but the group has made some fundamental advances that will allow for the integration of culverts and pave the way for additional assert integration and mapping of MATS information in the future.

In addition to the major integration task, the group has also started the development of two ancillary tools for Operations use:

- Web Mapping Site – site accessible through internet browser containing GIS base mapping data and field inventory culvert data as well as available historic district data.

- Web Reports – Two web reports to aid in the selection of culvert data from the GIS database. The first report allows users to select culverts from a specific district, town, route and mile marker returning a basic report table of information on the culverts in that segment. The second report is an inspection report for individual culvert showing the full inspection information from the most current inspection.

As this group continues to move forward with MATS integration and the associated tools the idea is to tighten the data flow so that the work or inspections of either division feeds the dataset updating the master data. Being the first major asset to move from a PDD inventory into the MATS environment, this process has been a learning experience for all involved. Though there is a considerable amount of work to do in this area we have high aspirations for next year's work.

Additional Benefits

The main goal of the SSCI is to locate, inspect and inventory small culverts in an effort to improve our management and programmatic improvement of the small culvert asset. In the programs effort to achieve this goal, there have been secondary benefits that have been realized:

- **Existing MS4 data –** in conjunction with the Operations Stormwater Compliance Management Program the Agency has an inventory of stormwater features within MS4 areas. That stormwater has been absorbed and incorporated into the SSCI to be properly maintained and updated as needed. The data is then provide as needed to Stormwater Compliance Management Program.

- **Rutland MS4 data –** in anticipation of the Rutland area being designated in the near future as a MS4 area, the standard SSCI collection procedure was appended with the additional needs of the MS4 program. This effort saved the expense of double collection and will ensure the integration of Agency data into the future.

- **Paving Projects –** With the number of issues that have arisen over the recent years on completed pavement projects, the paving section has requested information regarding cross culverts. This data has been incorporated into plans for several interstate projects for the use of the construction resident on site.

Conclusion

To date, the Highway Safety and Design, Asset Management Unit maintains an inventory of 14,468 small culverts and 10,468 drop inlet structures. Inspection teams have investigated 735 miles of highway including 541 miles of interstate and 92 miles of state and US routes.

Culverts barrels that were able to be assessed for condition, 93% were recorded as being in fair or better condition. With the access constraints of small culverts in the inventory, 45% were not able to be assessed for barrel condition. Inlet and outlet treatments were recorded at 89.5% in fair or better condition

The data we have collected to date will provide important location information for our daily operations use, project level programming as well as system wide planning. As we continue to collect data, we will continue to improve our approximation of the field conditions. The better we can understand our statewide system and the engineering and economic needs of our drainage system, the more efficiently and effectively we can manage the small culvert asset.